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Multi-sensor Platform for Indoor Air Quality Monitoring

Yuwei SHEN[1], Rouba ALRAMMOUZ[1], Marc FISCHER[1], Maxime MINOT[1], Riadh LAKHMI[1], Jean-Paul VIRICELLE[1], Mathilde RIEU[1]
[1] *Mines Saint-Etienne, Univ Lyon, CNRS, UMR 5307 LGF, Centre SPIN, F-42023 Saint-Etienne, France*

yuwei.shen@emse.fr

Summary:

Indoor air pollution has been a rising threat for public health. This study presents an indoor air quality monitoring platform integrating multiple sensors. It adopts calibration and compensation algorithms in order to improve gas measurement accuracy. A neural network-based gas recognition algorithm is also proposed. This approach promises more effective real-time IAQ monitoring for public health protection.

Keywords: indoor air quality, gas sensors, multi-sensor platform, neural networks

Background, Motivation and Objective

Indoor air quality (IAQ) is crucial for public health, as individuals typically spend around 80% of their time indoors. The World Health Organization reports that indoor air pollution causes over 3 million fatalities each year. Common indoor pollutants include carbon monoxide, volatile organic compounds, particulate matter, aerosols, and biological contaminants. These pollutants often originate from building materials, combustion from cooking appliances and fireplaces, and can be carried in from outdoors. The enclosed nature of indoor spaces condenses the concentration of these pollutants, resulting in a variety of health issues over both short and long exposure periods. Therefore, developing monitoring systems of indoor air quality is recognized as essential for health protection. Many multi-sensor platforms for IAQ monitoring were reported [1]. However, the literature either focuses on the advancement in sensing materials [2] or on gas identification using neural networks without any prior calibration or compensation algorithms [3]. The aim of this work is to develop a digital multi-sensor platform using commercial sensors for real-time IAQ monitoring.

Description of the System

Seven indoor air pollutants sensors were chosen for our application. They are capable of detecting a broad spectrum of indoor air pollutants within their exposure limits (Table 1). Since gas sensors are sensitive towards temperature and humidity changes, a temperature and humidity sensor for temperature and humidity compensation is included to complement the chosen set sensors. All eight sensors were then integrated onto a single printed circuit board, as shown in Figure 1.a. In order to facilitate real-time monitoring, data from the sensors are seamlessly transmitted and displayed via a dedicated Labview application. This integration enables continuous surveillance, empowering users with timely insights into indoor air quality dynamics.

The developed multi-sensor platform was characterized, calibrated and trained in the gas sensing test bench shown in figure 1.b. Our testing environment contains dual exposure chambers, offering precise control over airflow and humidity levels through a LabVIEW interface. It also enables sensor characterization under a mixture of up to 5 pollutants simultaneously.

Tab. 1: Target gases and their limits of exposure

Target gas	TVOC	HCHO	NO_2
Limit of exposure	750 ppb	16 ppb	1 ppm
Target gas	CO	CO_2	PM
Limit of exposure	35 ppm	3000 ppm	15 mg/m3

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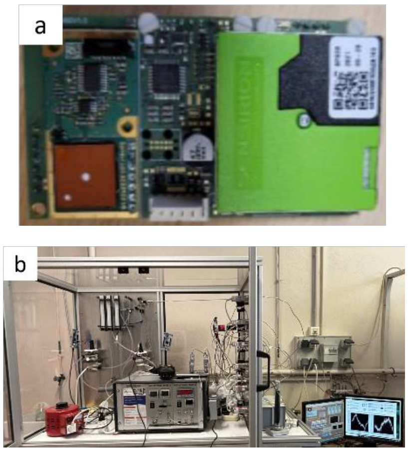

Fig 1.a. Multi-sensor board; b. Test bench at Mines Saint-Etienne.

Results

To ensure optimal performance, the sensors were first exposed to a variety of gases, including CO, NO_2, ethanol, acetone and various humidity levels. This step aimed to assess sensor sensitivity and selectivity across different pollutants. Figure 2 provides a representative illustration of the TVOC sensor's response, showcasing its pronounced sensitivity to VOCs while also highlighting potential interference from CO and humidity.

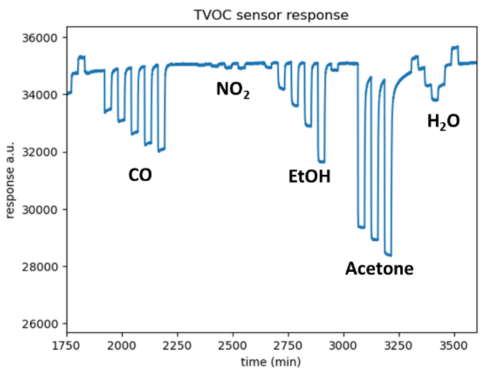

Fig 2. TVOC sensor's response under different exposure of CO, NO_2, ethanol, acetone, and humidity.

Following the initial calibration process, the sensor was exposed to various absolute humidity levels, in order to mitigate the impact of temperature and humidity variations. To effectively compensate for these environmental factors, we implemented a linear compensation algorithm, as illustrated in Figure 3. Furthermore, an algorithm for gas recognition and concentration detection employing neural networks is under development. This algorithm promises enhanced precision in identifying and quantifying pollutant concentrations, thereby enhancing the sensor's efficiency in indoor air quality monitoring.

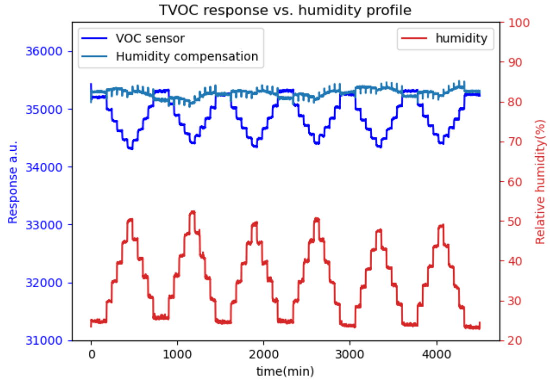

Fig 3. Temperature and humidity compensation for the TVOC sensor.

Conclusion

In this work, we have developed a multi-sensor platform tailored for indoor air pollutant detection. Through calibrations under diverse pollutants and the implementation of a humidity compensation algorithm, we have ensured the platform's reliability and gas measurement accuracy. A neural-network-based gas recognition algorithm is under development for gas identification. This approach promises to enhance the efficiency of multi-sensor platforms with embedded neural networks not only in terms of indoor air pollutants identification and quantification, but also in terms of data management, memory management and power consumption.

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